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Working Paper

Considerations for an Operational* Earth-Sensing System

General

The earth's land surface is made up of two basic types of features - fixed and time variant. The term fixed is arbitrarily applied to those features which change so slowly that they need to be mapped no more often than once per decade. On the other hand time variant features or phenomena may change their position or form in a matter of seconds or it may take several years before the changes warrant their remapping.

To map the fixed earth features an imaging system of high geometric fidelity is required and as of today this calls for the so called mapping camera which records on stable base film. Thus the mapping of the fixed earth features from either aircraft or spacecraft calls for the <u>film return</u> mode of remote sensing. Perhaps some time variant features whose changes can be measured in something less than a decade also justify this mode.

For the survey of the more rapidly changing earth features the film return mode loses its practicality - particularly where space systems are involved. For recording such features and the changes thereto, a space borne imaging device with electronic data transmission offers th most promising solution. This has already been demonstrated with

*Whereas manned spaceflights are suitable platforms for sensing experiments only unmanned systems are considered suitable for operations.

meteorological satellites and ERTS-A should demonstrate this concept by the multispectral imaging of the earths surface at a resolution (photographic criterion) in the order of 150 to 200 meters.

Current studies for EOS propose an ERTS follow on which will involve more powerful sensors and thus higher resolution. However it is doubted that this approach will lead towards an operational system and may, in fact, discredit the concept that surveying the land areas from space can be economically justified. The reason for this skepticism is that time variant features are limited area-wise as well as time-wise. At any given time it is doubted that as much as 1% of the earth land areas are worth sensing for such purposes. In other words a system that is not highly selective with respect to both area and time will acquire a mass of imagery of which at least 99% will be worthless. In fact it may become impractical to even find the 1% which is worth processing.

Before defining any earth sensing space flights beyond ERTS the following basic factors must be considered.

MODES

Aircraft. Altitudes up to about 25 km (82,000') appear to be practical and there is no basic reason why the aircraft must be manned at such altitudes. Sensor data is normally film returned but can be electronically transmitted. Where the area of concern has dimensions of only a few hundred kilometers, where frequency requirements are moderate, and where the resolution requirement exceeds 10 meters - aircraft provide the logical solution - assuming, of course that the area is accessible to aircraft.

Space, sun synchronous, electronic data transmission. This is the mode utilized by the meteorological satellites and defined for ERTS. It is ideal for obtaining global coverage at intervals of from 12 hours to perhaps, a month apart. However in imaging the globe or major portions thereof on a sequential basis the problem of data bulk and data handling becomes paramount. Low resolution global cover is manageable and practical for meteorology. ERTS is of a resolution and frequency where the data therefrom may or may not be manageable but any higher resolution global systems of this mode will probably prove impractical because of the mode's inherent lack of selectivity.

Space, sun synchronous, film return. This mode combines the advantages of photography with (potential) global coverage. By utilizing large (30/46) metric camera(s), mapping of the land areas of the world (except for those habitually cloud covered) can be accomplished. Ground resolution of such a system is 10 to 20 meters from a nominal 200 km altitude. Very high resolution camera systems which provide limited coverage can also be employed in this mode but their practicality for civil use is doubtful.

Space, geosynchronous, electronic data transmission. This mode has been demonstrated by the ATS satellite which carried a small TV camera and demonstrated the mode's unique capability with respect to observing time - variant meteorological phenomena. An earth sensing system would require a tracking telescope with a primary collector of at least 1 meter diameter which would resolve earth surface features in the order of 20 to 50 meters.

Resolution of about 10 meters is perhaps a practical limit for this mode. This mode, with its orbit defined by the ecliptic, will optimize solar illumination of the earth and it is the only one which permits continuous or high frequency sensing of time variant phenomena - subject only to condition of visibility. Moreover a tracking telescope in this mode provides true selectivity in that it can be directed on the specific area of interest and thus will acquire only that information that is wanted.

BASIC REQUIREMENTS

The civil community has prepared long list of requirements which include a wide variety of areas, frequencies and resolution. The so called surveillance community obviously has a similar wide variety of requirements. The overlap between these two sets of requirements is large and the cold truth of the matter is that any good earth sensing system has both civil and military application. To design an earth viewing system that will really meet civil requirements and not be of military significance is impossible and should not be attempted. Even at the resolutions of ERTS, so-called authorities are complaining about information of a security nature that will be made available to others. Anything better than ERTS will obviously intensify this problem. On the other hand surveillance systems obviously meet many civil requirements - although probably not from an economic viewpoint.

Combining civil and military requirements as a basis for a single sensing system may appear to be an impractical dream but the development of international inspection and arms control could perhaps make this a reality. There is nothing new in this concept. It is the "Open Skies" policy proclamed by President Eisenhower and still accepted by the U.S. and many other nations. An inspection system must be overt - or at least available to those concerned with such activities- and it must also be capable of detecting items of military concern. Why shouldn't such a system also be used for monitoring the earth's resources and environment? If properly designed the system will meet both basic requirements. In the final analysis earth sensing is too complex and costly to be unnecessarily fragmented. One good system that ranges from the synoptic global view to the limited area view with appropriate spectral and spatial resolution (in the 10 meter range) is the logical answer. Surveillance satellites of higher resolution might still be required and flown as independant systems as long as countries feel they need and can afford them. However, the basic fact remains that an overt system can be used for surveillance purposes but a surveillance system can hardly be applied in an overt manner. The reason for this is that the image itself must be widely disseminated in order to meet the varied civil requirements.

SUGGESTED PLAN

Several steps must be taken towards developing an optimum remote sensing system of the earth. The following listing attempts to put such steps in chronological order:

1. 1972-73. Fly ERTS-A and perhaps ERTS-B to ascertain the practical limits of such repetitive, global, near real time systems.

2. 1972-73. Fly two or three overt automated film return satellites designed to map the U.S. and such other countries as desire such coverage and offer to participate.

3. 1972-74. Design and orbit a tracking telescope of at least one meter diameter primary collector size in geosynchronous mode to observe the earth from the plane of the ecliptic. Such a system to include electronic data transmission and be complementary to a lower resolution geostationary satellite such as SMS (GOES).

4. 1972-75. Objectively evaluate the four modes against all legitimate requirements for earth sensing (civil, military and inspection).

5. 1975-79. Design and initiate an operational earth sensing system. Based on the existing state-of-the-art and known requirements this system would include the following:

a. One or two polar low resolution satellites of the Nimbus-ERTS type for global coverage.

b. A series of film return satellites to map the earth's land areas at a frequency of perhaps a decade.

c. A system of geosynchronous satellites which can scan at low resolution (GOES) or image selected areas at high (10-50 m) resolution. Perhaps six satellites with the high resolution capability are required for global coverage.

d. Aircraft systems to meet the localized requirements for better than 10 meter resolution.

e. High resolution surveillance systems as required.

6. 1972-79. Conduct a comprehensive R&D program based on the overall earth sensing requirements and which will include the following:

a. Sensor technology - passive and active systems.

b. Aircraft technology - higher altitudes, automation, etc.

c. Spacecraft technology - to include the extension of satellite life through servicing and shuttles (manned and unmanned).

d. Data transmission, reduction evaluation and dissemination.

IMPLEMENTATION

Defining the role that various agencies and nations might play in finalizing an overall earth sensing system is beyond the scope of this paper. However someone must take the lead if such is to become a reality. The U.S. Interior Department is a logical focal point for such action. It has been a leader in the field of earth sensing for civil purposes and has such a reputation on a world wide basis. It is time for Interior officials to suggest that civil and military earth sensing systems cannot and should not be separated. A good system can be put to economic use with respect to earth resources and also provide the truth about matters related to international inspection and arms control. Interior in cooperation with other resource oriented agencies should spell out the civil requirements as should those agencies concerned with inspection and arms control. Then an agency such as NASA, based on the combined input and guided by proper agency representation, should design and fly the system components. Operational control would, of necessity, be vested with the highest level of government.

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ARGO HISTORY

In January 1967 the President's Science Advisor, Dr. [redacted] initiated a program to test, on a limited basis, the utility of classified reconnaissance products as a tool for earth resource assessment. This study was concurred in by the DCI, Mr. Helms, and the Deputy Secretary of Defense, Mr. Vance. This program was called ARGO in order to provide an unclassified name for the effort. The objectives of the initial ARGO effort were: 25X1

1. "To evaluate the existing classified satellite usefullness for physical resource surveys, and its bearing on the design of future systems."

2. "To develop a small cadre of civilian agency personnel who will know what information is available and how the photography can be used."

3. "To produce a resource inventory of a particular area of interest to USAID to show what might be done with the existing photography and to determine whether the work should be extended."

A group of scientists from the Department of Interior (USGS), Department of Agriculture, Department of State (AID), Department of Commerce (C&GS now NOAA), National Aeronautics and Space Administration and the Corps of Engineers (Civil Works) were cleared to perform this study. At the same time a ARGO steering group, under the chairmanship of the Office of Science and Technology, was established. Membership of this steering group was comprised of departmental representatives of the above organization. The DCI appointed the Chairman of COMOR as an observer and DoD appointed the Deputy Director for Mapping, Charting and Geodesy, DIA as an observer. The NRO and NPIC provided technical advisors to the effort. This arrangement provided two essential functions. It allowed the DCI to monitor the activities of the group to insure the protection of the classified materials and provided for the acquisition of satellite materials, on a non-interference basis, in response to the civil agencies requirements without involving the DCI in formulating or validating these requirements.

The initial ARGO Study Report concluded that the photographic satellite reconnaissance systems had application in varying degrees to many problem areas such as:

Forestry and Agriculture Land Use

Topographic Mapping

Hydrolical Mapping

Disaster Relief Planning

Urban Development

Marine Sciences

Geology and Mineral Exploration

The report also concluded the civil agencies were quite limited in their use of this material because of the requirement for special security clearance of personnel, physical security of facilities, handling the photography, and lack of modern equipment to extract the information from the photography.

Upon completion of the initial study the ARGO working group was disbanded and continued studies and pilot projects were to be done by the individual civil agencies under the auspices of the ARGO Steering Committee.

During the period from 1969-1972 the ARGO Steering Committee was quite effective in defining collection requirements for specific projects which were then acted upon by the DCI through the COMIREX and USIB mechanism. Also personnel clearance requirements were also efficiently handled in this manner. The ARGO Steering Committee was not successful, however, in establishing the comprehensive civil agency requirements for satellite imagery or in fostering truly operational use of this imagery by the civil agencies, except for limited topographic mapping by the USGS. The reasons for the lack of success of the ARGO effort in these two areas vary between agencies but to a large measure they can be summed as follows:

1. The desire of the civil agencies to operate their own satellite systems;

2. Competition for dollar resources to start new programs which depended on collection of imagery which they could not fully control and the continuance of their current programs.

Since the disestablishment of the Office of Science and Technology, the ARGO effort has been dormant. The Office of Management and Budget, in 1972, conducted a total Federal Mapping Study and has again pointed up the potential cost saving of using the intelligence photographic satellites to collect imagery for the civil agencies as they pass over the United States. In order to accomplish this under the limitations placed on the use of national intelligence resources by the National Defense Act of 1947 as amended, these photographic satellites must be acting in response to civil agency requirements, not intelligence agency requirements. The NSC has proposed that the NASA chaired

Interagency Coordinating Committee for the Earth Resources Survey Program (ICCERSP) assume responsibility for the establishment of the civil agencies imagery collection requirements and that it form a civil applications panel under the Secretary of Interior to receive, evaluate, consolidate, standardize, prioritize, and transmit to the DCI through the Chairman of COMIREX all requests for classified reconnaissance data from the civil community. The panel will act as the interface between civil users and the intelligence collectors, recognizing that the Director of Central Intelligence will not be involved in judgments concerning civil users needs or priorities and that collection for this purpose will remain incidental to foreign intelligence collection.

The President approved a USIB recommendation on 23 November 1973 to ease the security restrictions associated with the use of satellite reconnaissance imagery. This action now permits the imagery from the older photographic systems to be handled at the Secret level. It also permits the use of the material from the current camera system flown in support of Defense Mapping Charts and targeting which has characteristics very similar to the NASA 18 inch Skylab system to be handled at this security level.

I believe that the costs of satellite photography are of such a magnitude that the country must extract all information contained in the imagery whether it be of intelligence interest or for other interests. In this regard, I do not believe there should be duplicative systems procured, but rather have the civil (NASA) systems designed to meet those requirements which the reconnaissance systems cannot meet. I also believe that the NSC proposal will permit the "one truck-two users" approach which will protect the reconnaissance systems and separate intelligence influence from domestic programs.